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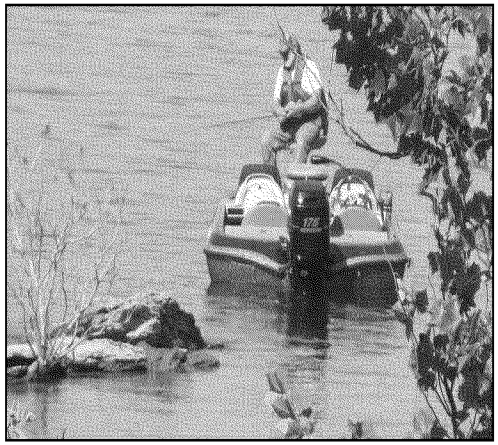

Numeric Nutrient Criteria for Lakes
Missouri Criteria and Framework

February 29, 2016

History – Numeric Nutrient Criteria in Missouri

- 2009 – Numeric nutrient criteria for lakes approved by Missouri Clean Water Commission, submitted to EPA
- 2011 – EPA disapproves most of the nutrient criteria portion of the rule
- 2015 – Department develops alternate nutrient criteria in response to EPA disapproval

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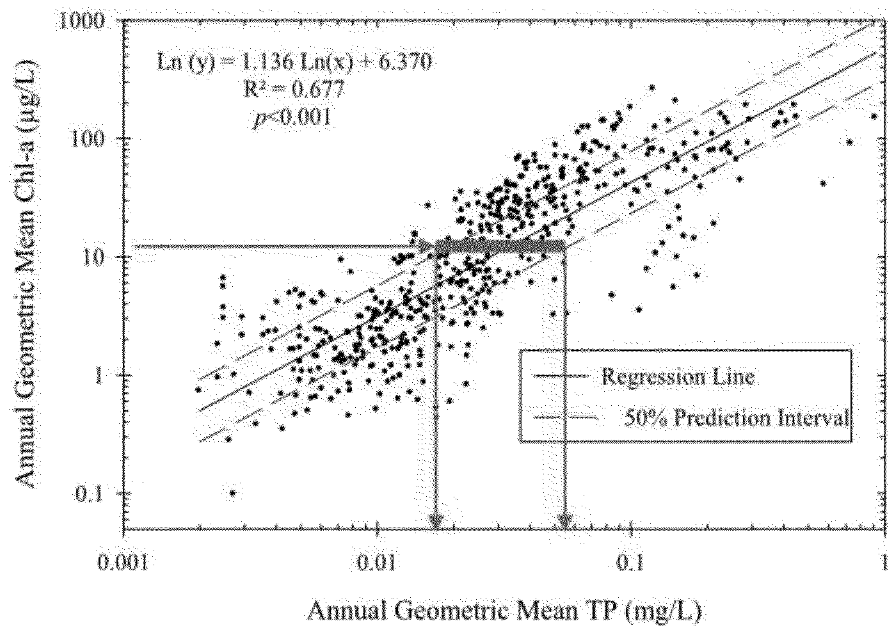
Challenges – Lake Nutrient Criteria Development

- Variable ecosystem response
- Nutrients are not toxic
- Nutrients are necessary for aquatic life
- No direct link between nutrients & designated use
- Response variables (algae/chl-a) more closely linked to designated use

Lake



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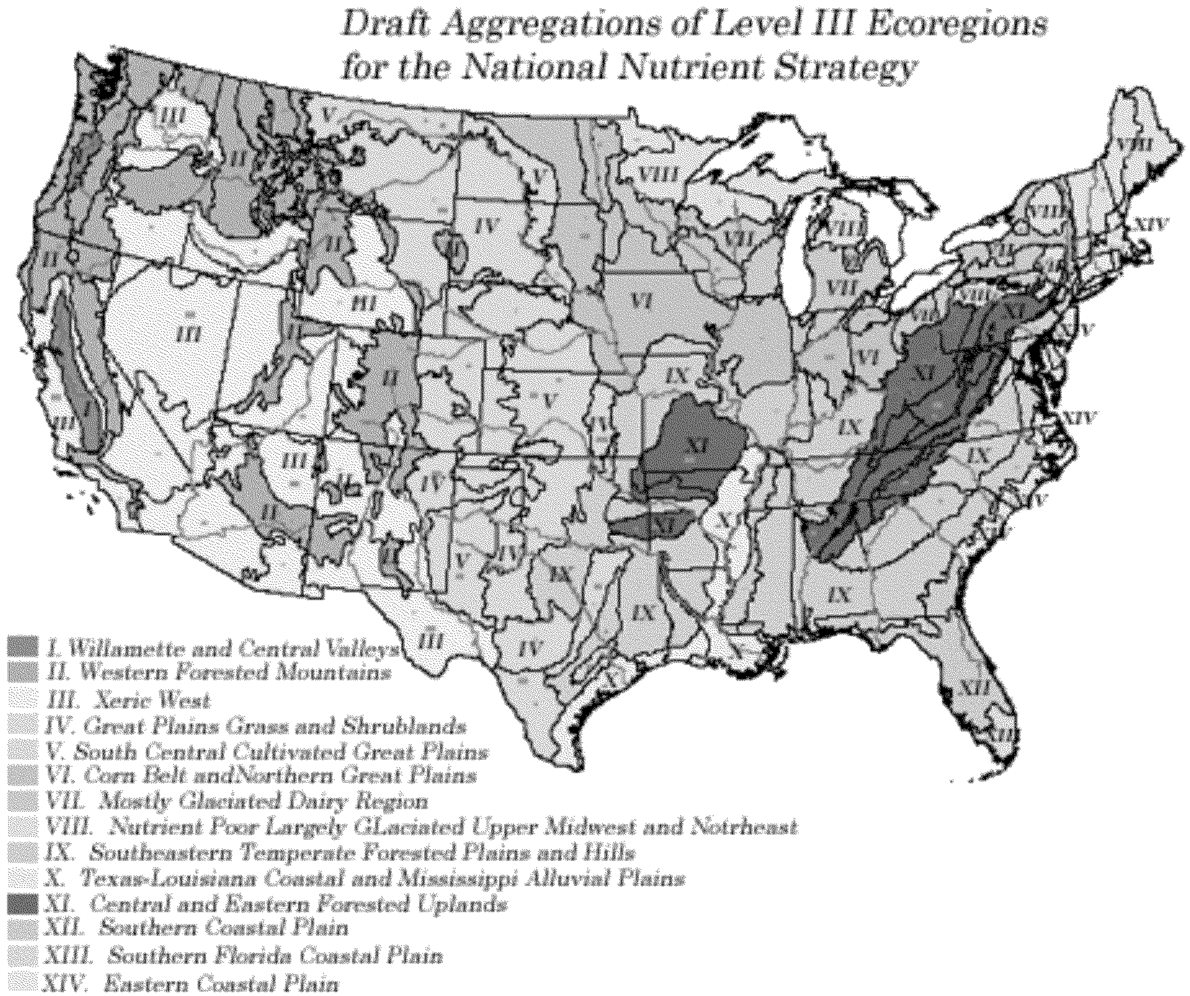
Nutrient Criteria – Reflect Regional Differences



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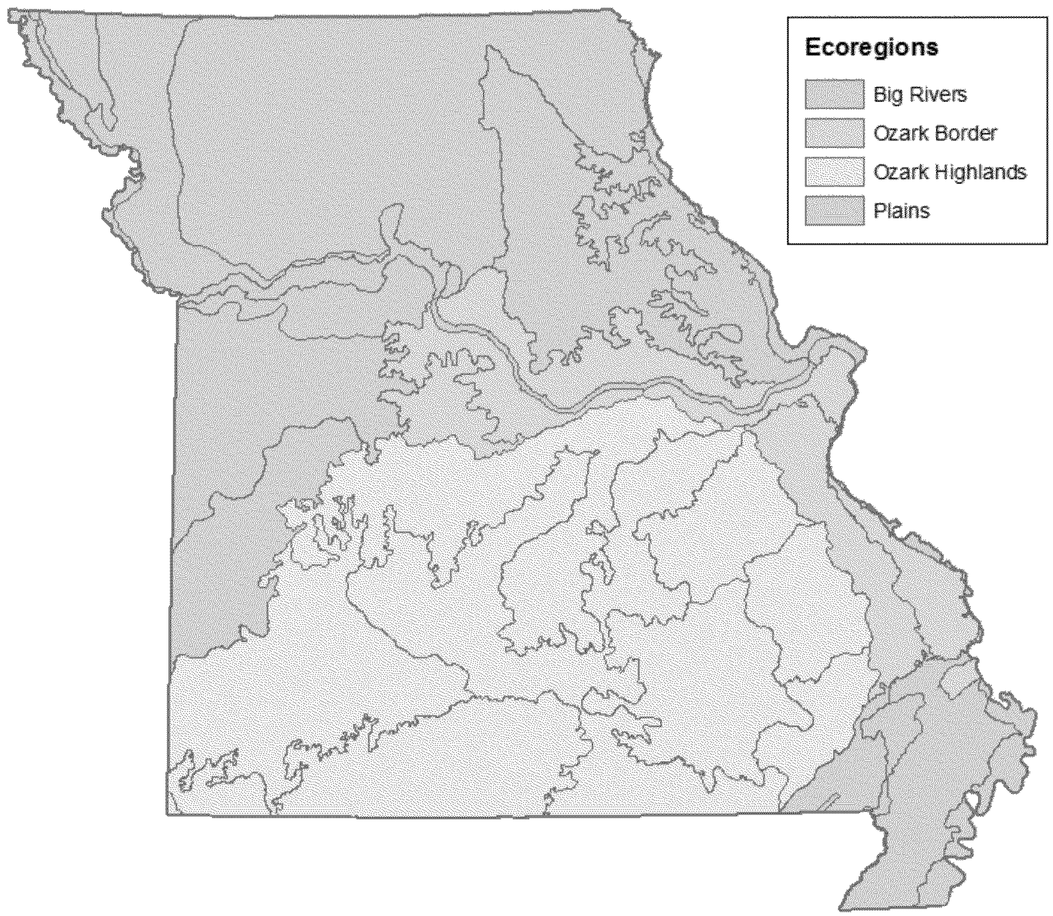
EPA Approved Lake Nutrient Criteria

State	Lake Chl a	Lake TP	Lake TN	Chl a Magnitude (ug/L)	TP Magnitude (ug/L)	TN Magnitude (ug/L)
Alabama	Partial	No	No	5-27	--	--
Arizona	No	Partial	Partial	--	115-160	1,600-1,900
California	Partial	Partial	Partial	0.6-1.5	8-300	100-4,000
Colorado	Partial	Partial	No	4-18	7.4-30	--
Florida	Statewide	Statewide	Statewide	6-20	10-160	510-2,230
Georgia	Partial	Partial	Partial	5-27	0.5-5.5 lbs/ac-ft/yr	3,000-4,000
Illinois	No	Partial	No	--	50	--
Maryland	Partial	No	No	10-30	--	--
Minnesota	Statewide	Statewide	No	3-30	12-90	--
Missouri	Partial	Partial	Partial	1.5-11	7-31	200-616
Nebraska	Partial	Partial	Partial	8-10	40-50	800-1,000
Nevada	Partial	Partial	Partial	*	25-330	250-1,000
New Jersey	No	Statewide	No	--	50-100	--
North Carolina	Statewide	No	No	15-40	--	--
Oklahoma	Partial	Partial	No	10	--	--
Oregon	Statewide	Partial	No	10-15	241 lbs/yr	--
Rhode Island	No	Statewide	No	--	25	--
South Carolina	Partial	Partial	Partial	10-40	20-90	350-1,500
Tennessee	Partial	No	No	18	--	--
Texas	Partial	No	No	5-20	--	--
Vermont	No	Partial	No	--	10-54	--
Virginia	Partial	Partial	No	10-60	10-40	--
West Virginia	Statewide	Statewide	No	10-20	30-40	--
Wisconsin	No	Statewide	No	--	5-40	--
Other States	No	No	No	--	--	--

Nutrient Criteria – Reflect Regional Differences



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Nutrient Criteria – Reflect Regional Differences

Source - EPA

Source - MDNR

Nutrient Criteria – Protect Designated Uses

Total P

Chl-a

Total N

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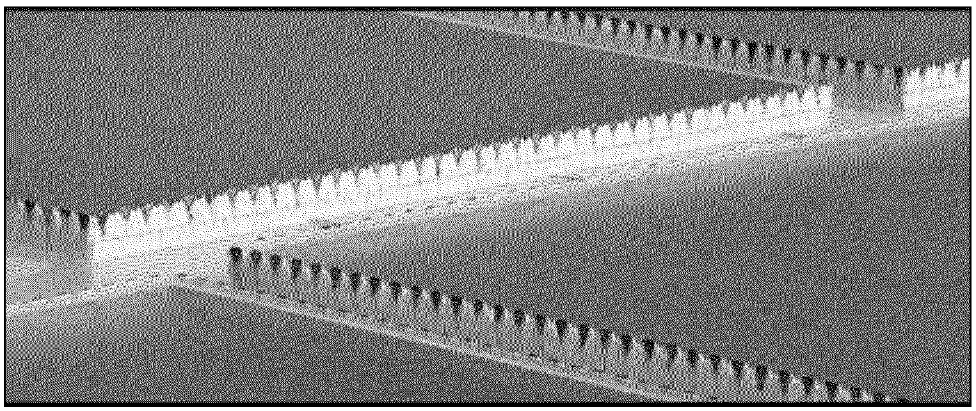
Drinking Water Supply (DWS) Designated Use

- 10 CSR 20-7.031(1)(C)6
- Drinking Water Supply – *Maintenance of a raw water supply which will yield potable water after treatment by public water treatment facilities.*



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DWS Designated Use & Eutrophication

- Increased organic compounds that serve as precursors for disinfection byproducts
  - Trihalomethanes
  - Haloacetic acids
- Taste and odor compounds
  - Trans-1,10 dimethyl-trans-9-decalol (geosmin)
  - 2-methylisoborneol (MIB)
- Cyanobacterial toxins
  - Microcystins
  - Cylindrospermopsin
  - Anatoxin-a
  - Saxitoxin

Disinfection Byproducts – MCL Violations

System	Waterbody	Total Trihalomethane	Total HAA
Adrian	Adrian Lake, South Grand River	2014	--
Bowling Green	Lake #1, Lake #2	2011	--
Breckenridge	Breckenridge Lake	2010-2012	2010
Bucklin	Mussel Fork Creek, Bucklin Lake	2011-2012	2010
Daviess Co PWSD 3	Lake Viking	2010-2011	--
Fredericktown	Fredericktown Lake	--	2014
Garden City	Garden City Lake, New Lake	2010-2013	--
Hamilton	Marrowbone Creek, Hamilton Lake	2010-2012	--
Lamar	Lamar Lake	2010	--
Maysville	Willowbrook Lake	2010-2011, 2013-2014	--
Memphis	Memphis New Lake, Memphis Old Lake	2013	2013

Note: This table does not represent an exhaustive list of all DBP MCL violations from 2010-2014. This table excludes system violations where the waterbody could not be identified or was not a reservoir, or where water quality data could not be located. Additionally, where a system pulls water from multiple sources, it is unclear which source caused the MCL violation.

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Disinfection Byproducts – Data Summary

Drinking Water Reservoir	Region	Long-term Chl Geomean (μg/L)	Range of Annual Chl Geomeans (μg/L)	Period
Adrian Lake	Plains	33	29-37	2011-2012
Bowling Green Lake Old	Plains	6	0.3-27	2003-2010, 2013
Breckenridge Lake	Plains	13	5-62	2003, 2010-2011
Bucklin Lake	Plains	23	9-55	2010-2012
Garden City #1	Plains	38	38	2011
Garden City #2	Plains	49	49	2012
Lamar Lake	Plains	47	31-76	2003-2010, 2013
Memphis Lake #1	Plains	44	44	2009
Memphis Lake #2	Plains	35	34-35	2005-2006
Vandalia Reservoir	Plains	21	16-29	2011-2012
Lake Viking	Plains	7	5-14	2003, 2005-2012
Willowbrook Lake	Plains	28	24-36	2005-2006
Fredericktown Lake	Ozark High.	31	28-34	2004-2005, 2008

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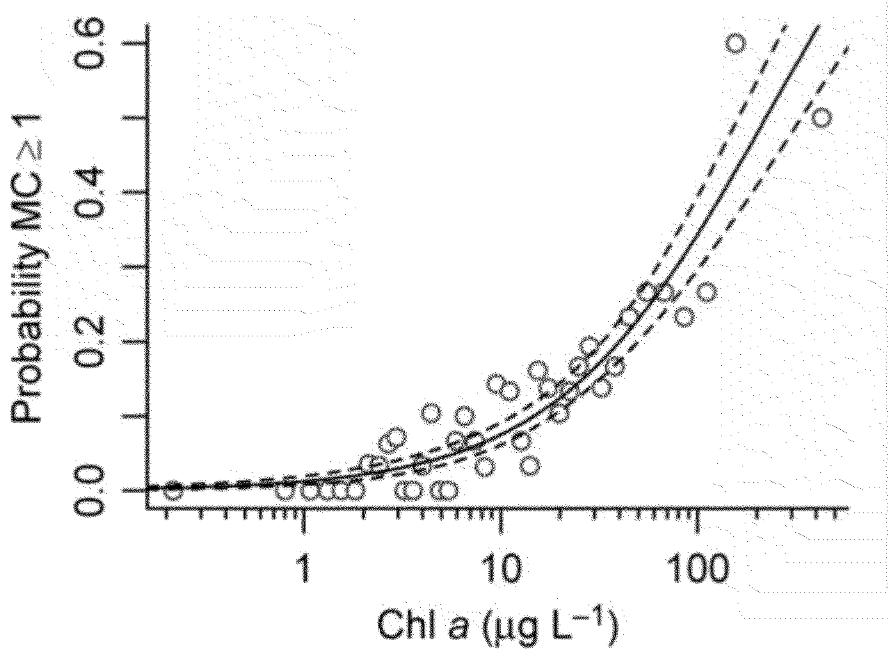
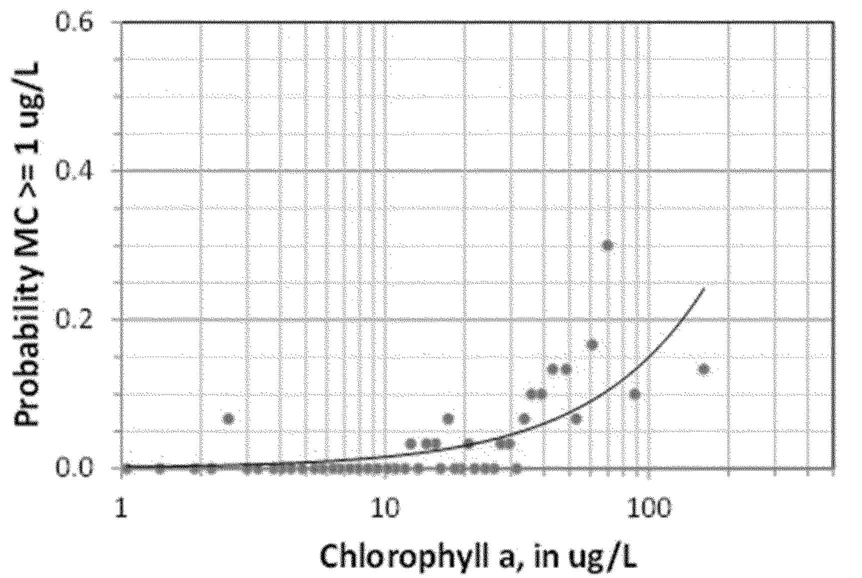
Microcystin – National vs Missouri Dataset

National Dataset (Yuan, 2014)



Missouri Dataset
(Graham and Jones, 2009)



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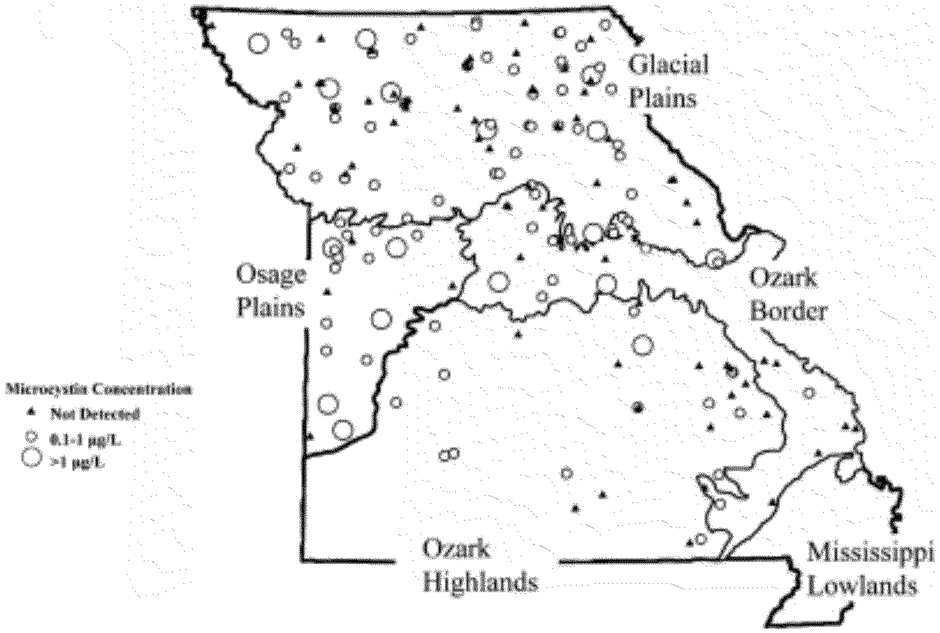
Microcystin in Missouri Reservoirs



Graham and Jones, 2009

Total Microcystin (µg/L)	n	Chl-a Median (µg/L)	Chl-a Range (µg/L)
nd	1,082	11	1-252
0.1-1	271	26	1-267
>1	49	49	2-131

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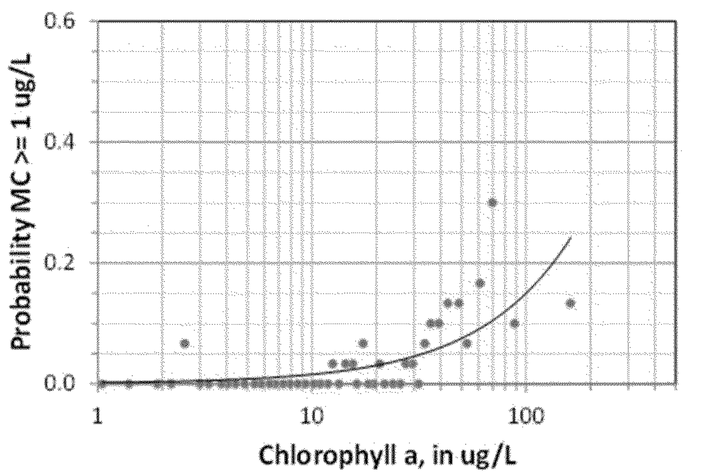
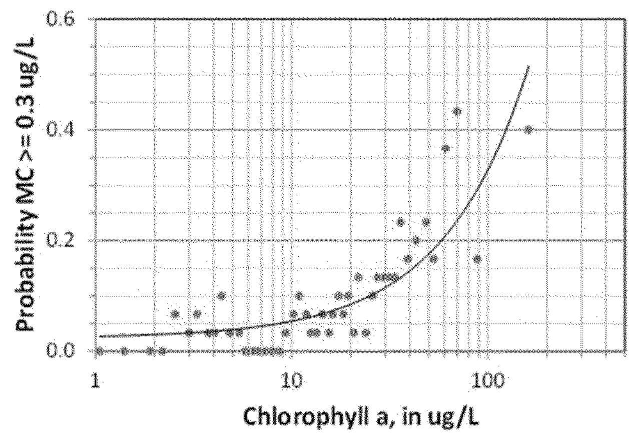
Microcystin (MC) in Missouri Reservoirs



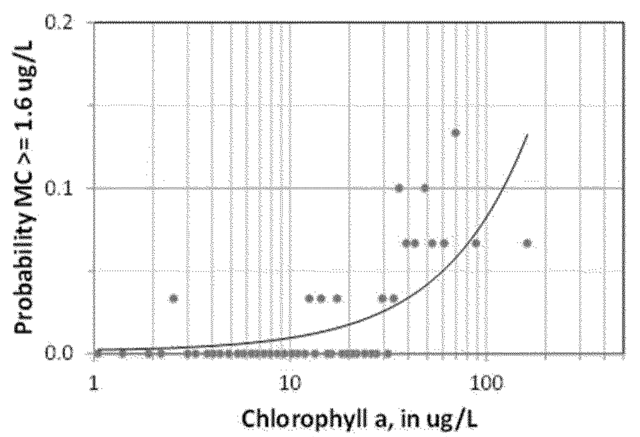


Probability Comparison of different
Health Advisory (HA) levels for Microcystin (MC)

0.3 μg/L = HA < 6yo

1.0 μg/L = WHO recommended DWS guideline

1.6 μg/L = HA > 6yo to adult



DWS Nutrient Criteria & Screening Values

Table L: Lake Ecoregion Nutrient Criteria and Long-Term and Short-Term Screening Values (µg/L)

Lake Ecoregion	Chl-a Criterion	Short-Term Screening Value			Long-Term Screening Value		
		TP	TN	Chl-a	TP	TN	Chl-a
Plains (DWS)	26	65	1,000	26	26	560	10
Plains (AQL)	40	100	1,300	40	50	850	20
Ozark Border (DWS)	26	70	1,000	26	29	600	10
Ozark Border (AQL)	22	60	960	22	26	580	9.0
Ozark Highland (DWS)	26	52	1,000	26	24	550	10
Ozark Highland (AQL)	15	34	700	15	18	430	7.0

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Aquatic Habitat Protection Designated Use

10 CSR 20-7.031(1)(C)1.A. – Warm Water Habitat (AQL)

Waters in which naturally-occurring water quality and habitat conditions allow the maintenance of a wide variety of warm-water biota—

(I) Warm water habitat (Great River);

(II) Warm water habitat (Large River);

(III) Warm water habitat (Small River);

(IV) Warm water habitat (Creek);

(V) Warm water habitat (Headwater); and

(VI) Warm water habitat (Lake or reservoir).

* However, Missouri lakes and reservoirs typically do not host a "wide variety" of biota due to maintenance or management of warm water sport fishery conditions by state or federal agencies.

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MU/MDC Sport Fish Study

- Objective - Examine the relative importance of watershed characteristics, impoundment morphology, water quality, and species interactions in explaining difference in relative abundance, growth, and size structure of largemouth bass, bluegill, redear sunfish, white crappie and black crappie among small Missouri impoundments.
- Findings
  - Numerous influences affect sport fish populations.
  - Variable associated with predation, competition, a nd lake fertility were most important in explaining variation in sport fish demographics.
  - Largemouth bass predation was a strong force in st ructuring sunfish and crappie populations.
  - Bluegills are positively associated with largemout h bass
  - TP and Chl were positively associated with growth a nd size structure of largemouth bass, bluegill, redear sunfish, and black crappies.
  - For black crappie PSD-P and largemouth bass PSD th ere seemed to be a threshold at Chl of 40-60 ug/L, beyond which these size structure va riables declined.
  - Largemouth bass and redear sunfish CPE declined wit h increased lake fertility but were especially low for most lakes with TP>100 ug/L or Chl > 40-60 ug/L.

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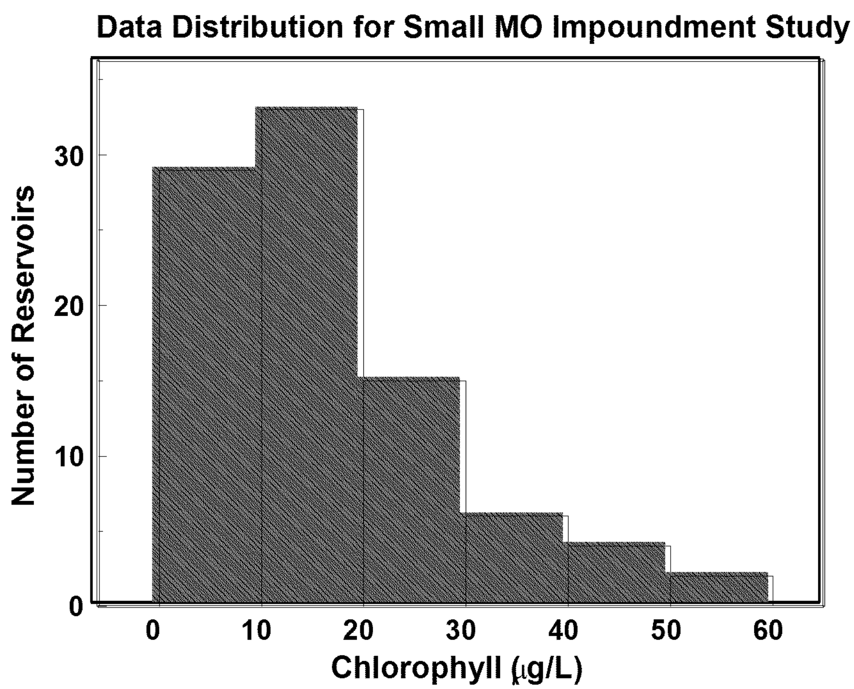
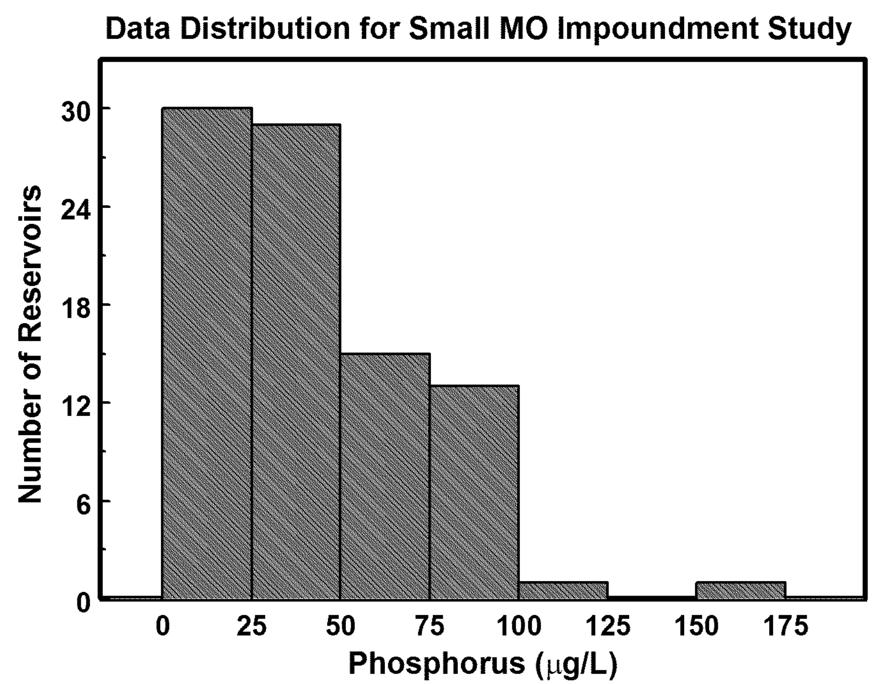
MU/MDC Sport Fish Study





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MU/MDC Sport Fish Study

	Primary fish species			
Physiographic section	Small impoundments (<1,000 acres)	Large reservoirs (≥1,000 acres)	Water quality conditions[a] Mean (range)	Proposed criteria[b]
Glacial Plains	Largemouth bass, bluegill, white crappie, black crappie, redear sunfish, green sunfish, gizzard shad, common carp (invasive), channel catfish (stocked)	Largemouth bass, bluegill, white crappie, black crappie, gizzard shad, common carp (invasive), channel catfish, flathead catfish, blue catfish, freshwater drum, white bass, bigmouth buffalo, smallmouth buffalo, river carpsucker, longnose gar, shortnose gar	Chla: 21.6 μg/L (2.5-114.3 μg/L) Secchi depth: 0.9 m (0.4-2.6 m)	Chla: 30 μg/L Secchi depth: 0.6 m
Ozark Border	Largemouth bass, bluegill, white crappie, black crappie, redear sunfish, green sunfish, gizzard shad, common carp (invasive), channel catfish (stocked)	N/A	Chla: 13.6 μg/L (1.5-35.7 μg/L) Secchi depth: 1.4 m (0.7-4.0 m)	Chla: 22 μg/L Secchi depth: 0.7 m
Ozark Highlands	Largemouth bass, bluegill, white crappie, black crappie, redear sunfish, green sunfish, gizzard shad, common carp (invasive), channel catfish (stocked)	Largemouth bass, smallmouth bass, spotted bass, bluegill, walleye, longear sunfish, rock bass, white crappie, black crappie, walleye, gizzard shad, threadfin shad, common carp (invasive), channel catfish, flathead catfish, blue catfish, freshwater drum, white bass, bigmouth buffalo, smallmouth buffalo, river carpsucker, river redhorse, black redhorse, logperch, brook silversides, paddlefish, longnose gar, shortnose gar	Chla: 7.3 μg/L (1.1-25.3 μg/L) Secchi depth: 2.0 m (0.8-4.3 m)	Chla: 15 μg/L Secchi depth: 0.9 m

[a]Data from Jones et al. (2008).
[b]Justification for these criteria are listed below.

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AQL Nutrient Criteria & Screening Values

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Nutrient Criteria – Connect WQS Goals

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Nutrient Criteria and Screening Values

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Nutrient Criteria – Assessment Process